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ABSTRACT

A multi-method approach to the diagnosis of attention deficit hyperactivity disorder was investigated for the purpose of developing an assessment model that could detect the subjects' level of functioning within Mirsky's (1987) four phases of attention and to determine if the primary distractors were by auditory, visual, or combined stimuli. Thirty-two subjects, ages 9 to 12, were assessed using a battery consisting of 8 different instruments, each one selected for its design to assess at least one of the 4 phases of attention as well as one of the stimulus categories. The results from the battery of tests were compared with the Continuous Performance Task variables (Mirsky, 1987) and two teacher rating scales. Two stepwise multiple regressions and two canonical correlations were used to analyze the data, and the results indicate extremely high multiple correlations with the two teacher ratings and with identifiable dimensions of the battery that assess two out of Mirsky's four phases of attention. Practical implications are discussed. (Contains 17 references and 3 tables.) (Author/SLD)

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Developing a Battery for Assessing Attention Deficits in Children

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Abstract

A multi-method approach to the diagnosis of attention deficit hyperactivity disorder was investigated for the purpose of developing an assessment model that could detect the subjects' level of functioning within Mirsky's (1987) four phases of attention and to determine if the primarily distractors were by auditory, visual, or a combined stimuli. Thirty-two (32) subjects, ages nine to twelve, were assessed using a battery consisting of eight different instruments, each one selected for their design to assess at least one of the four phases of attention as well as one of the stimulus categories. The results from the battery of tests were compared with the Continuous Performance Task variables (Mirsky, 1987) and two teacher ratings scales. Two stepwise multiple regressions and two canonical correlations were used to analyze the data, and the results indicate extremely high multiple correlations with the two teacher ratings and with identifiable dimensions of the battery that assess two out of Mirsky's four phases of attention. Practical implications are discussed.

Developing A Battery For Assessing Attention Deficits in Children

When faced with making a differential diagnosis concerning attention deficit hyperactivity disorder, the clinician encounters considerable difficulty related to problems within the current diagnostic system and with the approach to assessment (Fletcher, Morris, & Francis, 1991). The traditional assessment procedure relies heavily on self-report and observation (Anastopoulos & Barkley, 1992), and the difficulties encountered in using any rating scale are well documented (Issacs & Michaels, 1983; Walen & Henker, 1991). One perplexing problem common to any rating approach is the effect of potential response sets and biases. All too often, the frustrated parent's or teacher's extreme rating of a child reflects their own frustration more than the actual behavior of the child. Additionally, the clinician faces the problem of translating the ratings from these scales to a meaningful description of the child that can eventually lead to an effective treatment approach.

Anastopoulos and Barkley (1992) indicate that a useful adjunct to behavior rating scales are direct observational procedures. Many systems have been developed for this, but again, these approaches also have flaws that suggest observations be used only as an adjunct to but not the sole basis for evaluation and diagnosis. Some of these flaws include the effects of the observer on the observation process and the subtle influence of demand characteristics.

Anastopoulos and Barkley identify one additional category of assessment procedures that uses various continuous performance procedures in which simple recognition tasks are projected onto a computer screen or some other apparatus to assess various elements of attention. These approaches have been developed most prominently by Gordon (1983) and Mirsky (1987). Anastopoulos and Barkley (1992) indicate:

Despite their widespread usage, many of these measures do not possess satisfactory

> psychometric properties. Of even greater clinical concern is that these procedures are typically administered in clinic settings under relatively novel, one-to-one, high feedback conditions, which greatly reduces the likelihood of eliciting ADHD symptomology. (p.421).

These short comings indicate that CPT systems, observational approaches, and rating systems are best viewed as either useful adjuncts to or a part of a more comprehensive approach to assessment.

Mirsky (1987) and Goldstein and Goldstein (1990) reflect the most recent thinking in the area, namely that attention should be assessed from a multiphasic perspective. Mirsky's (1987) model of attention includes four parts (focusing, sustaining, shifting, and encoding), and he suggests that each area should be assessed by a variety of procedures. Miller (personal correspondence, April 1992) has suggested that, in addition to examining each component of attention, a thorough assessment procedure should be used to determine whether or not the child is distracted primarily by auditory, visual, or combined stimuli. The purpose of this study is to initiate the development of a multiphasic assessment approach to ADHD. The eventual goal of this line of research is to develop a multi-method approach that will: (1) assess all four components of attention; (2) assess the primary source of distractibility; and (3) provide an accurate description of the child that would ultimately lead to successful treatment planning.

Method

Subjects

Initially 42 subjects were recruited from several school districts in southe Oklahoma and Northern Texas. Classroom teachers from each districts referred children, some of whom

were suspected of having an attention deficit and an equal number of randomly selected non-suspects to provide a broad range of attention capabilities. Seven subjects had to be dropped from the study because they were not available for the second testing session. Additionally, three subjects were dropped from the data analysis due to the presence of multivariate outliers, leaving 32 subjects (16 suspected ADHD and 16 non-ADHD controls). Of the 19 males and 13 females, the ethnicity composite was as follows: 27 caucasians, 2 Native Americans, 1 hispanic, and 2 unclassified. The ages ranged from six to twelve years (mean=9.257, D_s=1.521) and consisted of: 4 six-year-olds, 4 eight-year-olds, 8 nine-year-olds, 12 ten-year-olds, 2 eleven-year-olds, and 2 twelve-year-olds.

Instruments

Predictor Variables

Eight instruments were included in the battery, each one selected for its ability to assess one of the components of attention and/or the primary source of distractibility. The reader is referred to the various test manuals for specific psychometric information on each of the tests selected; however, this brief description of each one will acquaint the reader with the purpose of the instrument.

Auditory Selective Attention from the Goldman-Fristoe-Woodcock Auditory Skills Test Battery The GFW measures a child's ability to selectively attend to a stimulus in a quiet situation and with three different types of background noise: white noise, cafeteria noise, and a voice (Goldman, Macalyne, & Woodcock, 1974). This instrument is one of the few that is available to measure sustained attention to auditory stimuli with and without the presence of a distractor.

Benton Revised Visual Retention Test The Benton is a test of vasoconstrictive ability that requires the subject to draw a series of ten designs arranged in three parallel forms which can be given under four possible administrations (Benton, 1974). The administrations chosen for this study were: Benton C - stimuli is reproduced with the card in full view; Benton A - 10 second exposure to the stimuli, removal of the card, and immediate reproduction from memory; and Benton D - 10 second card exposure, 15 second delay, and subsequent reproduction. This test was included to measure visual encoding, sustaining, and shifting.

Cognitive Control Battery The CCB is designed for use with subjects from 3 to 16 years of age (Santosstefano, 1988) and consists of three specific subtests:

1) The **Scattered and Scanning Test** is designed to measure how an individual surveys a visual field and also measures freedom from distractibility, sustained attention, and encoding,

2) The **Fruit Distraction Test** is designed to measure selective attention and freedom from distractibility,

3) The **Leveling and Sharpening Test** is a measure of how an individual constructs memory images and compares them with subsequent perceptions. It measures both sustaining, encoding, and shifting with visual stimuli.

Speech Sounds Perception Test The SSP, from the Halstead Reitan Neuropsychological Battery (Reitan & Davidson, 1974) uses nonsense syllables to test the individual's ability to attend to and process auditory stimuli and was included to measure encoding, shifting, and sustaining attention with an auditory stimuli.

Seashore Rhythm Test Also from the Halstead-Reitan Battery, it is designed to

assess an individual's ability to focus, shift, and sustain attention to nonverbal auditory stimuli.

The Peabody Picture Vocabulary Test. This test uses stimuli pictures to measure receptive vocabulary and was included in an attempt to measure the possible contributing factor of intelligence. The PPVT also provides a secondary measure of visual focusing, shifting, and encoding (Dun & Dun, 1981).

The Digit Span Subtest of the WAIS-III This subtest measures immediate auditory sequential memory by requiring the subject to repeat increasingly longer series of numbers both forward and backward (Wechsler, 1991) and was included as a measure of auditory focusing, encoding, and shifting.

Coding Subtest of the WAIS-III. This subtest was included to measure visual encoding and maintenance (Wechsler, 1991).

Criterion Variables

The three instruments used as dependent or criterion variables were two separate teacher rating scales and the Continuous Performance Task (Sunrise, 1991) which provided two different types of criterion variables. Each of these procedures is briefly described herein, but the reader is referred to the appropriate test manual for more detailed information.

Attention Deficit Disorders Evaluation Scale Developed by McCarney (1989), the school version is designed to assess the degree to which a student exhibits behaviors that meet the DSM-IIIR criterion for a diagnosis of ADHD based on 60 items rated on a 0 to 4 scale by the home-room teacher. The raw scores from the three sub-scales (Inattentive, Impulsive, and Hyperactive) can be converted to a percentile or to a standard score for comparison to other measures. The Inattentive Scale was the only one chosen as a criterion variable in this study.

Conner's Teacher Rating Scale-39. Designed to measure several aspects of disruptive behavior in the classroom (Conners, 1991), the CTRS-39 consists of seven scales which include: (1) Hyperactivity Scale, (2) Conduct Problem Scale, (3) Emotionally Indulgent Scale, (4) Anxious/Passive Scale, (5) Asocial Scale, (6) Daydreaming/Inattention Scale, and (7) Hyperactivity Index. The teacher rates the student on a four-point scale for each of the 39 items, and these ratings load onto the various scales. The total scores for each scale are converted to a t-score format. For this study, Scale A (Hyperactivity) was selected as a criterion variable.

Continuous Performance Task (CPT). This instrument is a continuous performance system originally developed by Allan Mirsky during the 1950's (Sunrise Systems, 1991). The CPT consists of a display box with capacity for presentation of visual and/or auditory stimuli, and for this study it was driven by a Texas Instruments Laptop Computer (LT286/12). "Visual stimuli are presented on a two inch square matrix of green LEDs, 21 high by 20 wide" (Sunrise Systems, P.1). Auditory stimuli may be presented in tones, letters, numbers, or words. Words are presented in up to 750 milliseconds in duration. "Audio bandwidth is 300 to 3000 Hertz, which is similar to telephones" (Sunrise Systems, p.2). The subject is required to monitor the stimuli and respond to specific target stimuli by pressing a simple hand-held switch. The computer keeps track of a variety of scores, but for this study the variables selected as criterion were the errors, omissions, and average mean time to respond to critical stimuli. Both types of stimuli can be paired with a distractorss of varying levels of either white noise (auditory) or degradation of the visual field.

The auditory stimuli selected for this study were from the d2_n-5.asf with the

following changes: minimum stimulus interval = 1500; maximum stimulus interval = 1500; standard duration = 500; available response time = 1999; and all other parameters were set to the default settings of the Sunrise system. This file created a mild-to-moderate background of white noise which acted as a mild distractor. The visual stimulus file used to sep up the CPT was the random 20 mask set. All parameters were at the default settings except for the following changes: minimum stimulus interval = 1500; maximum stimulus interval = 1500; standard duration = 200; available response time = 1699; and visual degradation was set to a foreground/background spin to create a moderate mask for distraction purposes. The total time on task for both the visual and auditory trials was from 10 to 12 minutes.

Procedure

After receiving a referral from each child's primary teacher, a signed informed consent form was secured from each parent or guardian, and if the data was to be shared with school personnel, a signed release was also obtained. Subject numbers were then assigned in order to maintain confidentiality, and no attempt was made to match names with numbers. Next, each referring teacher was asked to complete a CTRS-39 and a ADDES. The administration of all measures was divided into sessions. During the first session, each subject was administered all the tests in the battery except the CPT. Administration of the battery was conducted by a team of 3 to 4 graduate research assistants who were extensively trained in the proper administration of each test and in proper data collection procedures. Training was conducted by the project coordinator (a graduate research assistant), a licensed psychologist, and a certified school psychometrist. Research assistants set up testing stations in each school, typically in unused classrooms or the cafeteria. If more than one testing

station was set up in each room, portable dividers were used to limit outside distractions. Subjects were brought to the assessment center in groups of three to four and started simultaneously at each of the stations. When finished at one station, each subject was rotated to the next station which made it possible for three to four subjects to be assessed in a two hour period. At the second assessment session, scheduled approximately two to three weeks later, each subject was administered the auditory and visual CPT tasks. Each CPT task was recorded on disc by subject code number and later printed out to make a copy for the subject's file.

The project coordinator was responsible for setting up testing dates, keeping subject files together, entering data into computer files, and for some of the basic scoring. More advanced scoring was completed by the licensed psychologist and/or the certified school psychometrist. Prior to scoring the test, all individuals involved were unaware of each subject's status (ADHA suspect or control). The data was analyzed via the SYSTAT statistical package, Version 5.02 (Wilkinson, 1990).

Results

Data Preparation

A variety of procedures were used to assess the degree to which the data met the statistical assumptions of each procedure. The data transformations used were based on the

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Insert Table 1 about here

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procedures recommended by Tabachnick and Fidell (1989). First, normality of each of the variables was assessed through examination of the skewness and kurtosis. Any variables with a moderate positive skewness were transformed using a square root procedure. Variables with more severe skewness were transformed using either a log transformation or a 1/X transformation depending on the severity of the skewness. All variables eventually achieved normality after transformation. Linearity and homoscedasticity were assessed through examination of the residual scatter plots and through analysis of selected bivariate scatter plots. After transformation, there was no consistent indications of a violation of linearity or homoscedasticity. Univariate outliers were identified by converting all variables to z scores and transforming any score which exceeded +/- 3.00. Each univariate outlier was transformed by moving the outlier closer in to the remainder of the scores. This was accomplished by changing the value of the outlier to either one unit above or below the next closest score depending on its position with regard to the mean. Finally, multivariate outliers were identified by examining the Mahalanobis distances of each case when compared to the group centroid, and two were discarded from the data. Systat also identified an additional multivariate outlier through its own internal safeguard which is based on the analysis of the studentized residuals, and this case was also deleted from the data. Systat has built-in features to detect multicollinearity and singularity but none were detected. After deletion of all suspect cases, the data set consisted of 32 subjects.

Statistical Procedures

Four statistical procedures were used to analyze the data. The first two procedures were stepwize multiple regressions used to compare the battery with the ADDES Inattention Scale and the CTRS-39 Hyperactivity Scale. The regression of the battery with the

Hyperactivity Scale yielded a multiple R of .964, a squared multiple R of .930, and an adjusted multiple R of .903 after eight steps, which indicates that the test battery accounted for some 90% of the variance in teacher ratings. While statistical significance is not as critical in examining relationships, it is interesting to note that this regression was statistically significant at the .001 level. The final subset model can be seen in Table 2, and examination of it reveals that the most significant contributors were elements of the Fruit Distraction Test, the Scattered and Scanning Test and the Seashore Rhythm Test.

Insert Table 2 about here

The second multiple regression comparing the battery to the ADDES Inattention Scale yielded a multiple R of .823, a squared multiple R of .667, and an adjusted squared multiple R of .610 ($p < .0001$) after five steps. This indicates that some 61% of the variance of the Inattention Scale was accounted for by the battery. Analysis of Table 2 shows that the final subset model was again primarily influenced by the Seashore Rhythm Test, the Fruit Distraction and the Scattered and Scanning Test with minor contributions from the Leveling and Sharpening Test and the Voice only administration of the GFW. Across both criterion measures the battery yielded highly significant and strong multiple regressions indicating that the battery shows promise of being a valid method for assessing ADHD.

The second two analyses were canonical correlations designed to assess the degree to which the battery was related to both auditory and visual presentations of the CPT. In the first canonical correlation the tests that specifically focused on the auditory processes were compared with the auditory variables from the CPT. Of the three canonical variates

generated, the first was only one to approach statistical significance ($x^2=30.139$, DF=21, $P<.08$). It is suspected that the statistical nonsignificance on the other two variates may be due more to small sample size than actual nonsignificance. The corresponding canonical correlation for this variate was .705. Standardized canonical coefficients and canonical loadings are presented in Table 3.

Insert Table 3 about here

Analysis of Table 3 indicates that the most influential contributors to the battery were the Seashore Rhythm Test and the Speech Sounds Perception Test. Interestingly enough the GFW and the Digit Span Test contributed only slightly to the predictor linear composite. A redundancy index was calculated using the procedure described in Hair, Anderson, and Tatham (1987) with a value of .28, indicating that 28% of the variance in the criterion linear composite is accounted for by the test battery. Interpretation of these findings in light of the canonical loadings of the criterion variable suggests that this dimension of the battery is tapping into the auditory focusing and sustaining portion of the assessment model.

In the second canonical correlation, the portions of the battery which were primarily related to visual processes were compared with the results of the visual trials of the CPT. Again, only one canonical variate was statistically significant ($x^2=96.906$, DF=69, $P<.01$), with a canonical correlation of .976. Analysis of Table 3 indicates that the most significant contributors for the predictor linear composite were the Benton C correct score, the Benton D correct score, and the Fruit Distraction Test, Card 3 minus Card 2 Errors. Standardized coefficients and canonical loadings are presented in Table 3. The calculated redundancy index

was .238, suggesting that the battery composite accounted for almost 24% of the variance in the criterion variable. Interpretation of these findings in light of the canonical loadings of the criterion variable suggests that this dimension of the battery most closely measures visual sustaining attention and freedom from distractibility.

Discussion

The results of this study should be interpreted cautiously because of the extremely small sample size, low case to variable ratio and the use of multiple statistical procedures. The problem of multiple statistical procedures is partially overcome by the extremely low alpha levels achieved on most of the statistical procedures. However the combination of small sample size and use of regression based procedures does significantly increase the risk of a Type I error. For this reason, this study can only be viewed as exploratory and not a final statement on this issue, and additional studies using much larger samples need to be completed. Having stated this limitation, the extremely high multiple regressions between the battery and the teacher ratings demonstrate that this battery may be a promising and useful approach for assessing ADHD in children. Also, this relationship suggests that the battery in its current configuration is a good global predictor of the presence of ADHD. In addition, it far exceeds the usefulness of teacher ratings by offering a much richer description of the child and her/his abilities. Treatment planning and ultimately intervention strategies may be directly tied into these clinical snapshots of the child which have not been furnished by teacher ratings alone. The results of the canonical correlation are not completely unexpected since Mirsky (1987) indicated that the CPT data most closely taps into a sustained attention factor. The canonical correlations suggest that the battery is currently doing an adequate job of this as well. Other

criterion measures will have to be used in the future to establish the ability of the battery to assess all phases of attention. Once these criteria are identified, then additional factor and canonical analytic studies will need to be conducted to further establish the validity of the battery.

A fairly significant finding is the ability of the battery to assess sustained attention with both visual and auditory stimuli. A word of caution here is warranted. The finding that the battery is able to measure auditory and visual processes does not establish the existence of these subgroups among ADHD children. Further discriminant validity studies will need to be conducted to conclusively establish this.

Obviously it is too soon in the development of this battery to be able to calculate auditory or verbal index scores or to even begin to use a regression formula. However, the practical utility of this approach can still be used by the clinician immediately. Use of the test battery in combination with teacher and parental ratings of the child can provide the clinician with a rich and thorough foundation for making differential diagnoses and effective treatment planning of ADHD children.

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Table 1. Independent/Dependent Variables

Test/Subtest	Mean	Standard Deviation
Cognitive Control Battery		
Fruit Distraction Test		
Card 3-Card 2 Time	50.281	12.485
Card 4-Card 2 Time	42.969	11.729
Card 4-Card 2 Errors	49.969	7.882
Leveling/Sharpening Test		
First Stop Score	54.094	10.846
Number Correct Changes	50.063	9.161
Ration Score	51.156	9.942
Scatter Scan Test		
Mean Distance	43.344	9.355
Motor Tempo	54.063	10.102
Number Correct Shapes	60.031	8.863
Ratio Score I (MT/NC)	54.531	10.429
Ratio Score II (MT/TD)	50.688	8.434
Total Distance	60.250	10.683
Continuous Performance Task		
Audio 3 (masked)		
Mean Response Time	105.156	12.710
Omissions	12.938	12.996
Visual 2 (masked)		
Errors	2.397	1.628
Mean Response Time	88.469	12.232
Omissions	9.906	11.303
G-F-W Attention Test		
Cafeteria Noise	4.087	2.352
Fan Noise	48.594	2.352
Voice Noise	46.875	38.014
Peabody Picture Vocabulary	101.656	14.089
Halstead-Reitan Neurological Battery		
Seashores Rhythm Test	23.375	3.858
Speech Sounds Perception Test	3.110	1.099
WISC-III		
Coding	9.031	3.659
Digit Span	9.750	3.263
TEACHER RATING SCALES		
CTRS-39/Hyperactive Scale	56.906	15.045
ADDES/Inattention Subscale	8.813	3.979

Table 2. Multiple Regression Variables: Final subset model for (2) regressions.

a. Dependent Variable: Conners CTRS-39/Hyperactivity Scale

Independent Variables	Coefficient	Standard Coefficient
Constant	99.876	0.000
Age	9.705	0.383
Cognitive Control Battery		
Fruit Distraction Test		
Card 2 Errors	-0.990	-0.530
Card 3-Card 2 Errors	0.259	0.154
Leveling/Sharpening Test		
Number correct changes	-2.227	-0.134
Scatter/Scan Test		
Mean distance	-0.256	-0.147
Number correct shapes marked	0.381	0.334
Halstead-Reitlan Neurological Battery		
Seashore Rhythms Test	-2.524	-0.632
Speech Sounds Perception Test	2.532	0.184

b. Dependent Variable: Attention Deficit Disorders Evaluation Scale/Inattention Scale

Independent Variables		
Constant	-30.489	0.000
Cognitive Control Battery		
Fruit Distraction Test: Card 2 errors	0.209	0.430
Leveling/Sharpening: No.correct changes	0.077	0.175
Scatter Scan: Mean Distance	0.181	0.658
G-F-W Attention Test: Voice Noise	0.019	0.185
Halstead-Reitlan/Seashores Rhythm Test	0.685	0.658

Table 3. Linear Composites for two (2) Canonical Correlations.

a. Auditory Predictors

Variables	Loadings	Coef
G-F-W Attention Test		
Cafeteria Noise	0.234	0.009
Fan Noise	0.195	0.115
Voice Noise	- 0.122	- 0.200
Halstead-Reitlan Battery		
Seashore Rhythms Test	0.846	0.938
Spch Snds Percep	- 0.682	- 0.235
WISC-IV: Digit Span	- 0.024	- 0.090
Peabody PVT	0.003	- 0.201

Auditory Criterion

Variables	Loadings	Coef
Continuous Performance Task		
Audio 3 (masked)		
Errors	0.854	0.551
Mean Rspnse Time	0.479	0.044
Omissions	0.871	0.583

b. Visual Predictors

Variables	Loadings	Coef
Benton Visual Retention Test		
Admin A correct	0.044	0.592
Admin A errors	- 0.057	0.828
Admin C correct	0.428	0.927
Admin C errors	- 0.263	0.193
Admin D correct	0.328	1.636
Admin D errors	- 0.140	1.736
Cognitive Control Battery		
Fruit Distraction Test		
Card 2 errors	- 0.158	- 0.671
Card 2 time	- 0.001	0.440
Card 3-Card 2 errors	0.268	0.029
Card 3-Card 2 time	0.331	0.186
Card 4-Card 2 errors	0.278	0.401
Card 4-Card 2 time	- 0.129	- 0.036
Leveling/Sharpening		
First Stop Score	- 0.129	- 0.073
Number Crct Score	- 0.233	- 1.193
Ratio Score	- 0.292	1.109
Scatter/Scan		
Mean Distance	- 0.170	- 0.533
Motor Tempo time	- 0.265	- 1.834
No Correct Shapes	- 2.261	1.310
Ratio I (MT/NC)	0.127	- 1.788
Ratio II (MT/TD)	0.066	0.781
Total Distance	- 0.246	- 0.563
Peabody PVT	0.275	- 0.100
WISC-III: Coding	0.058	- 0.474

Visual Criterion

Variables	Loadings	Coef
CPT		
Visual 2 (masked)		
Errors	- 0.199	- 1.083
Mean Rspns Time	0.661	0.323
Omissions	0.526	1.083